FIG. 1

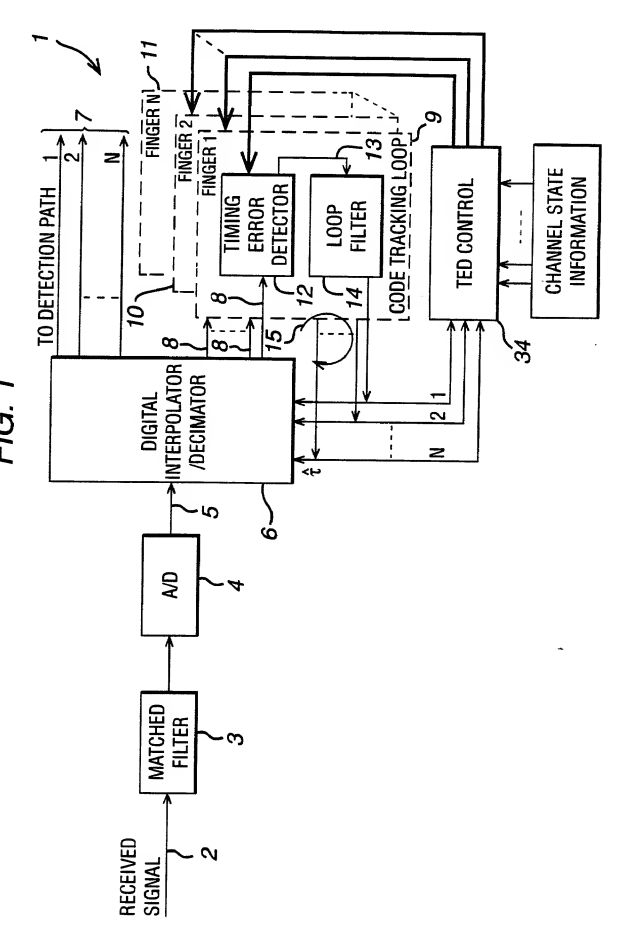

RECEIVED SIGNAL
2
MATCHED FILTER
3
A/D
4
DIGITAL INTERPOLATOR /DECIMATOR
5
6
TO DETECTION PATH
7
FINGER N
FINGER 2
FINGER 1
11
10
8
TIMING ERROR DETECTOR
12
LOOP FILTER
13
14
15
CODE TRACKING LOOP
9
TED CONTROL
34
CHANNEL STATE INFORMATION
1
2
N

FIG. 2

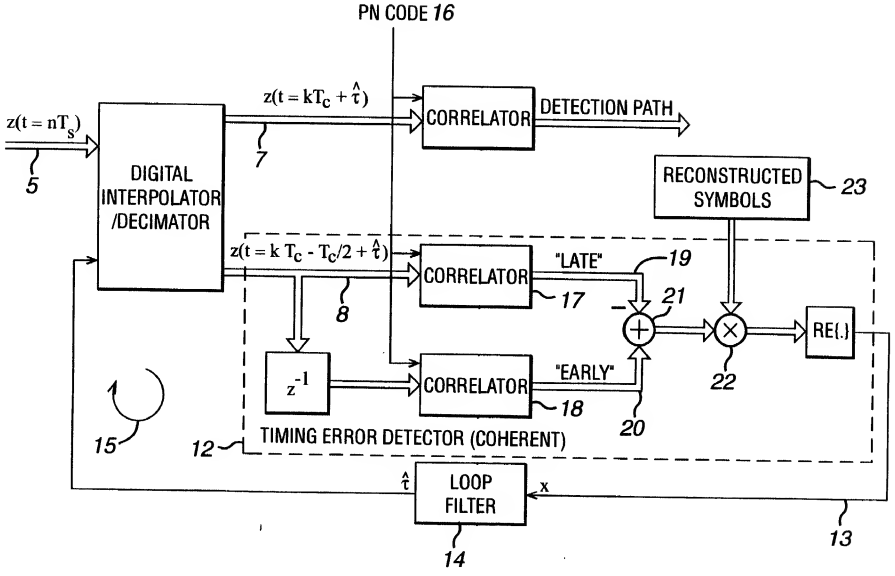

PN CODE 16
$z(t = nT_S)$
5
DIGITAL INTERPOLATOR /DECIMATOR
$z(t = kT_c + \hat{\tau})$
7
CORRELATOR
DETECTION PATH
RECONSTRUCTED SYMBOLS
23
$z(t = k T_c - T_c/2 + \hat{\tau})$
8
CORRELATOR
"LATE"
19
17
21
RE{.}
z^{-1}
CORRELATOR
"EARLY"
18
20
22
15
12
TIMING ERROR DETECTOR (COHERENT)
$\hat{\tau}$
LOOP FILTER
x
14
13

FIG. 3

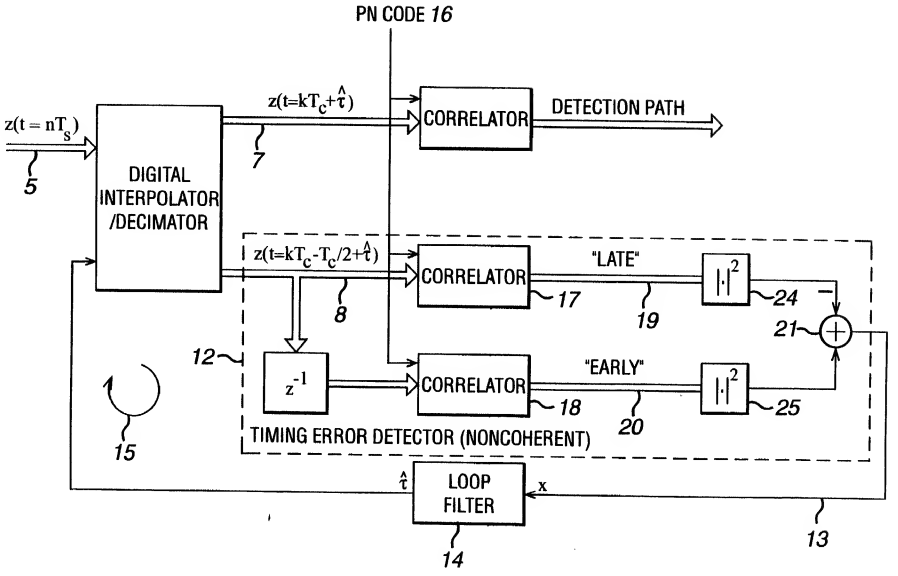

PN CODE 16
$z(t = nT_S)$
5
DIGITAL INTERPOLATOR /DECIMATOR
$z(t=kT_c+\hat{\tau})$
7
CORRELATOR
DETECTION PATH
$z(t=kT_c-T_c/2+\hat{\tau})$
8
CORRELATOR
"LATE"
17
19
$|\cdot|^2$
24
21
12
z^{-1}
CORRELATOR
"EARLY"
18
20
$|\cdot|^2$
25
15
TIMING ERROR DETECTOR (NONCOHERENT)
$\hat{\tau}$
LOOP FILTER
x
14
13

FIG. 4

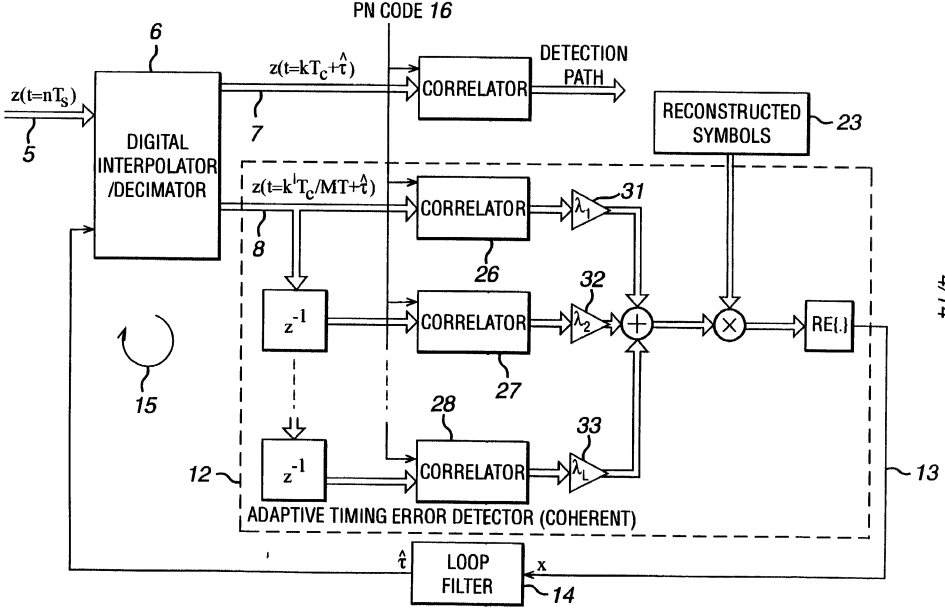

PN CODE 16
6
z(t=nT_s)
5
DIGITAL INTERPOLATOR /DECIMATOR
z(t=kT_c+τ̂)
7
CORRELATOR
DETECTION PATH
RECONSTRUCTED SYMBOLS
23
z(t=k^L T_c/MT+τ̂)
8
CORRELATOR
31
λ1
26
z^-1
CORRELATOR
32
λ2
RE{.}
15
27
28
33
12
z^-1
CORRELATOR
λL
13
ADAPTIVE TIMING ERROR DETECTOR (COHERENT)
τ̂
LOOP FILTER
x
14

FIG. 5

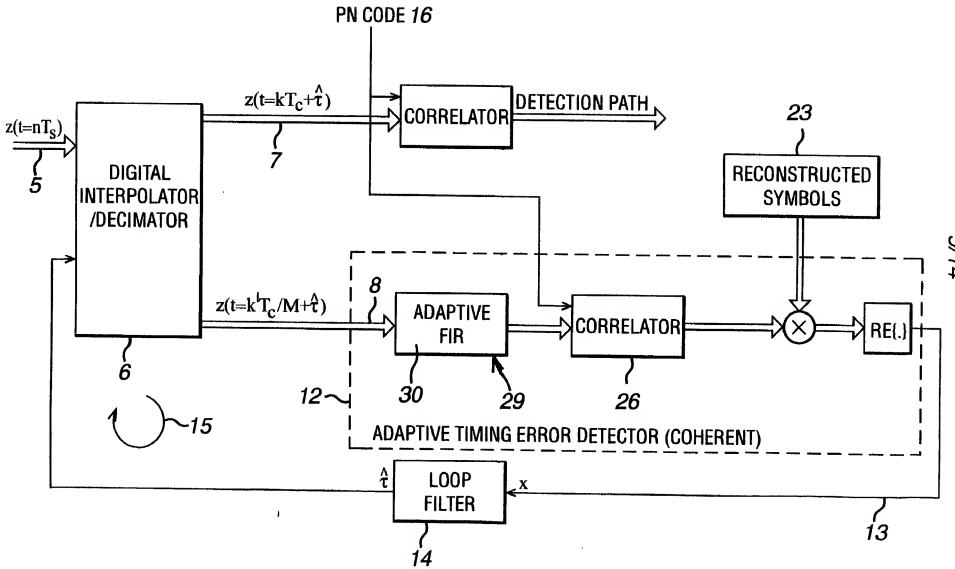

PN CODE 16
z(t=nT_S)
5
DIGITAL INTERPOLATOR /DECIMATOR
6
z(t=kT_c+τ̂)
7
CORRELATOR
DETECTION PATH
23
RECONSTRUCTED SYMBOLS
z(t=k'T_c/M+τ̂)
8
ADAPTIVE FIR
30
29
CORRELATOR
26
RE(.)
12
15
ADAPTIVE TIMING ERROR DETECTOR (COHERENT)
τ̂
LOOP FILTER
14
x
13

FIG. 6

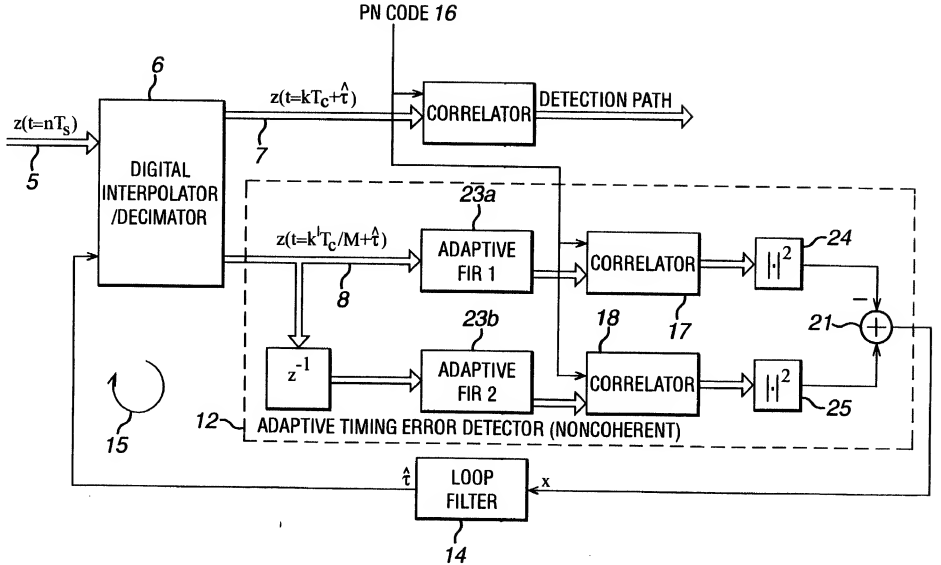

PN CODE 16
6
z(t=nT_s)
5
DIGITAL INTERPOLATOR /DECIMATOR
z(t=kT_c+τ̂)
7
CORRELATOR
DETECTION PATH
23a
z(t=k'T_c/M+τ̂)
8
ADAPTIVE FIR 1
CORRELATOR
|·|^2
24
17
21
23b
18
z^-1
ADAPTIVE FIR 2
CORRELATOR
|·|^2
25
15
12
ADAPTIVE TIMING ERROR DETECTOR (NONCOHERENT)
τ̂
LOOP FILTER
x
14

FIG. 7

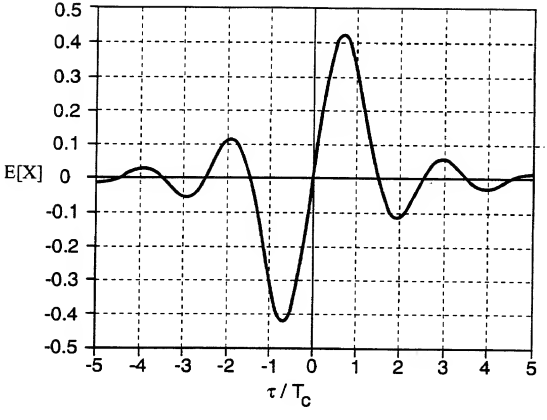

0.5
0.4
0.3
0.2
0.1
E[X] 0
-0.1
-0.2
-0.3
-0.4
-0.5
-5 -4 -3 -2 -1 0 1 2 3 4 5
τ / Tc

FIG. 8

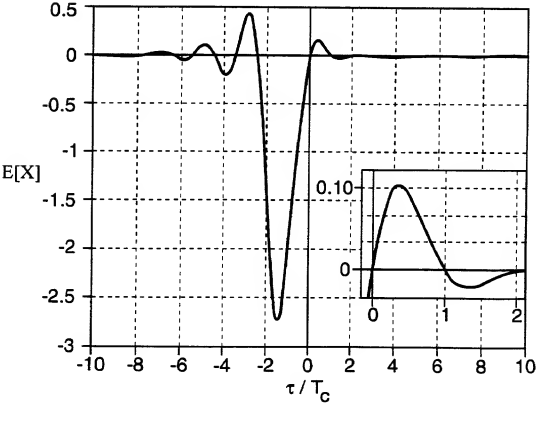

0.5
0
-0.5
-1
E[X]
-1.5
-2
-2.5
-3
-10 -8 -6 -4 -2 0 2 4 6 8 10
τ / Tc
0.10
0
0 1 2

FIG. 9

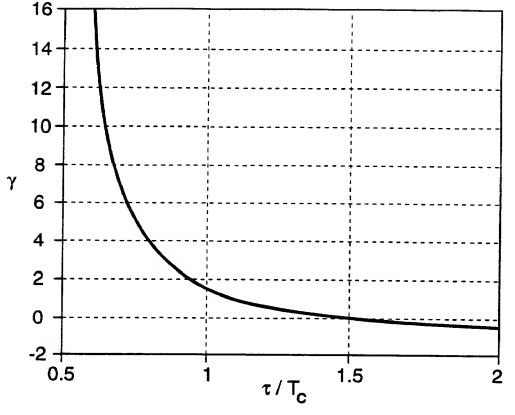


FIG. 10

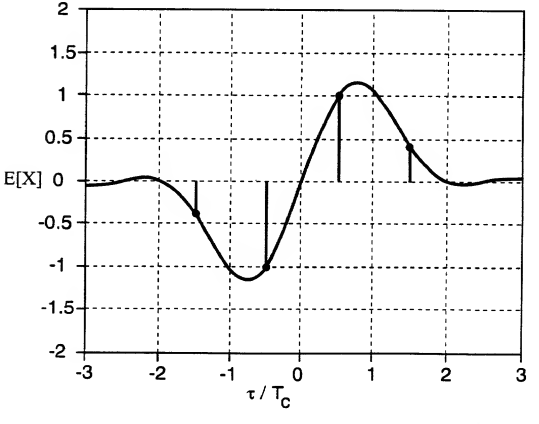


FIG. 11

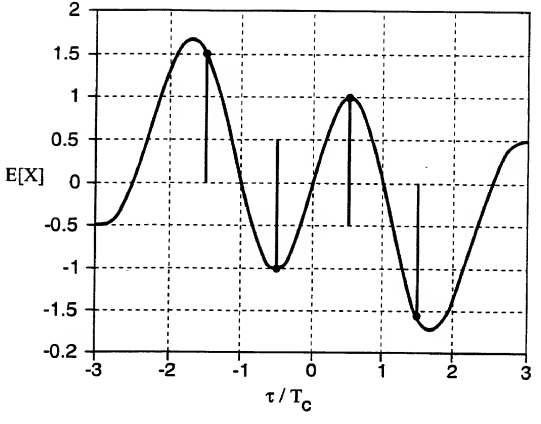

2
1.5
1
0.5
E[X] 0
-0.5
-1
-1.5
-0.2
-3
-2
-1
0
1
2
3
τ / T_C

FIG. 12

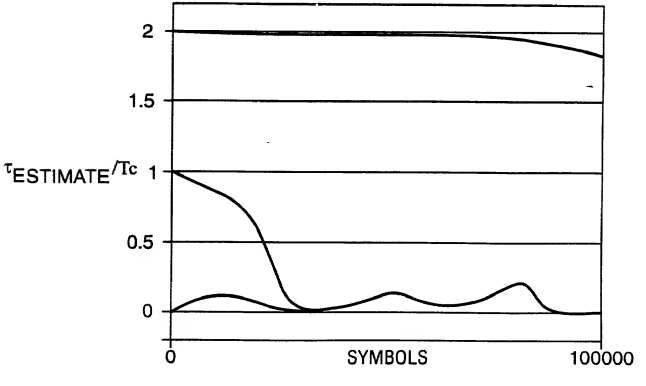

2
1.5
τESTIMATE/Tc 1
0.5
0
0
SYMBOLS
100000

FIG. 13

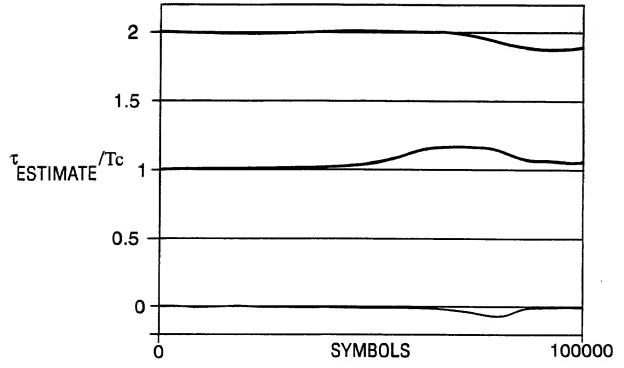

2
1.5
$\tau_{ESTIMATE}/Tc$
1
0.5
0
0
SYMBOLS
100000

FIG. 14

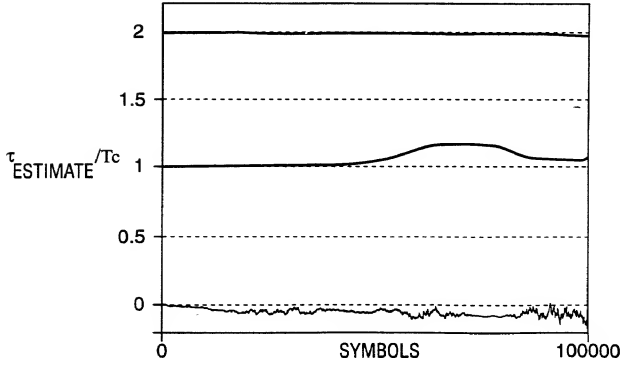

2
1.5
$\tau_{ESTIMATE}/Tc$
1
0.5
0
0
SYMBOLS
100000

FIG. 15

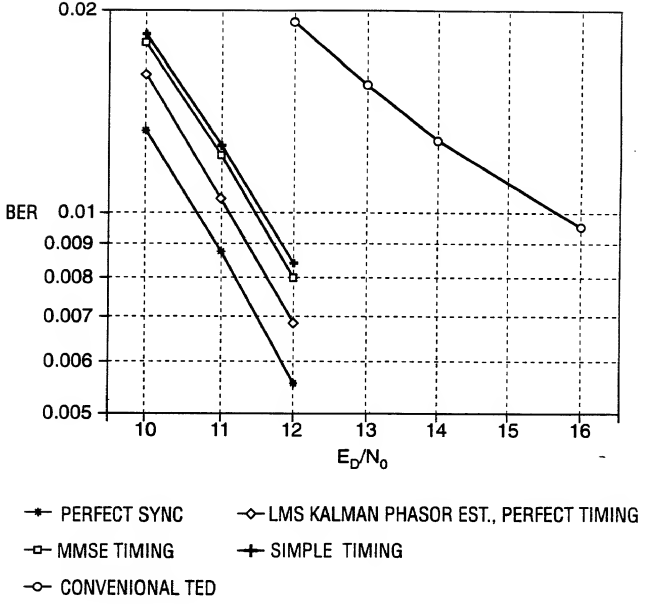

0.02
BER 0.01
0.009
0.008
0.007
0.006
0.005
10
11
12
13
14
15
16
E_D/N_0
PERFECT SYNC
LMS KALMAN PHASOR EST., PERFECT TIMING
MMSE TIMING
SIMPLE TIMING
CONVENIONAL TED

FIG. 16

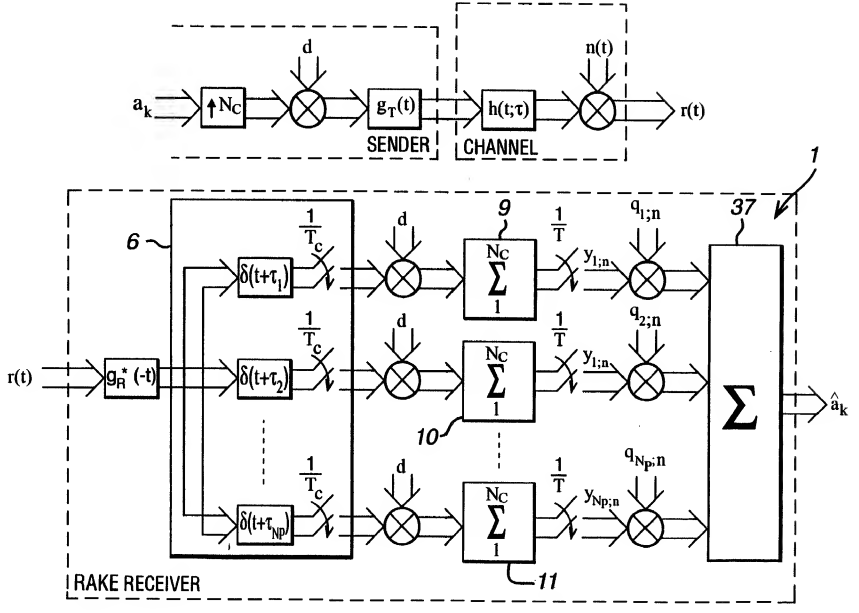

d
n(t)
a_k
$\uparrow N_C$
$g_T(t)$
$h(t;\tau)$
r(t)
SENDER
CHANNEL
1
6
9
37
$\frac{1}{T_c}$
$\frac{1}{T}$
$\delta(t+\tau_1)$
$\delta(t+\tau_2)$
$\delta(t+\tau_{Np})$
$N_C \sum_1$
$y_{1;n}$
$y_{Np;n}$
$q_{1;n}$
$q_{2;n}$
$q_{Np;n}$
Σ
$\hat{a}_k$
r(t)
$g_R^*(-t)$
10
11
RAKE RECEIVER

FIG. 17

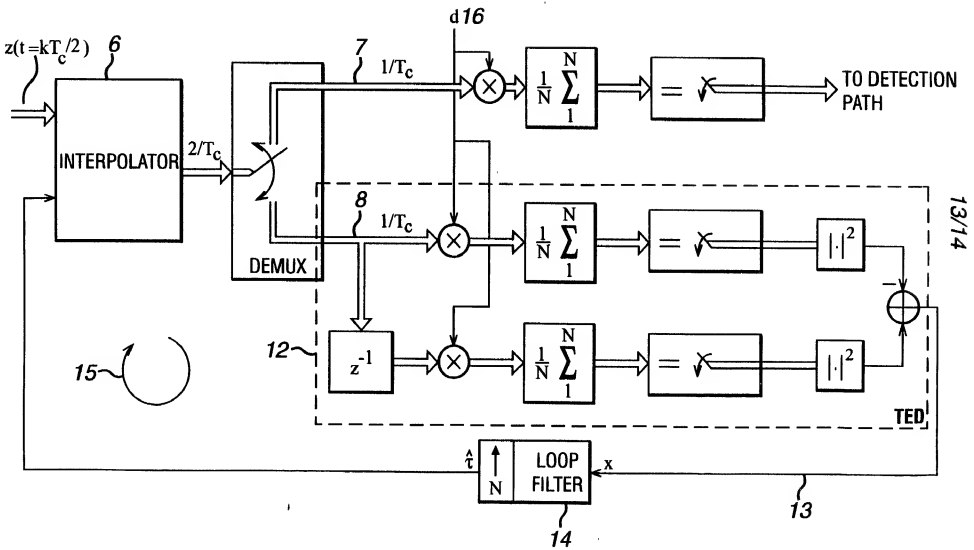
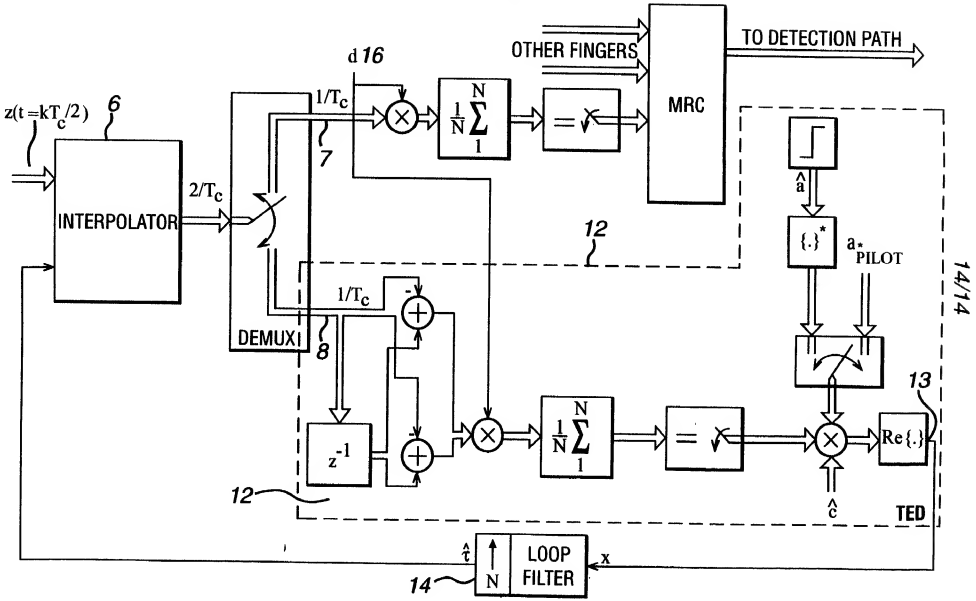

z(t=kT_c/2)
6
INTERPOLATOR
2/T_c
7
1/T_c
d 16
TO DETECTION PATH
DEMUX
8
1/T_c
13/14
12
z^-1
15
TED
LOOP FILTER
N
x
13
14

FIG. 18


z(t=kT_c/2)
6
INTERPOLATOR
2/T_c
DEMUX
7
8
1/T_c
d 16
OTHER FINGERS
TO DETECTION PATH
MRC
12
12
14/14
13
TED
LOOP FILTER
14
N
x
Re{.}
PILOT